Selected Mapping Based PAPR Reduction in WiMAX Without Sending the Side Information

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***Abstract*— WiMAX with its standard IEEE 802.16d/e is the advanced technology used for long range communication with high data rate. It is well known that the orthogonal frequency division multiplexing (OFDM) is a promising technique for getting high data rate in multi path fading environment. Hence the physical layer of WiMAX uses OFDM. But the main disadvantage of OFDM is the high peak to average power ratio (PAPR). In this paper we analyze how PAPR reduction is achieved using selected mapping (SLM) technique and simultaneously without sending the side information (SI) along with the OFDM symbol. Here the PAPR performance using complimentary cumulative distribution function (CCDF) plot and the probability of SI detection error performance have been evaluated as the criteria for WiMAX standard IEEE 802.16e.**

Keywords- Orthogonal frequency division multiplexing (OFDM); Peak to average power ratio (PAPR); selected mapping technique (SLM); complimentary cumulative distribution function (CCDF); Worldwide Interoperability for Microwave Access (WiMAX)

I. INTRODUCTION

IEEE.802.16 standard defines several wireless metropolitan area network (WMAN) technologies. WIMAX is a certification applied to 802.16 products tested by the WIMAX forum. IEEE 802.16d stands for fixed WIMAX and IEEE 802.16e stands for mobile WIMAX. In mobile WIMAX for downlink the modulation schemes to be used are QPSK, 16-QAM, 64-QAM and that for uplink are QPSK, 16-QAM, 64-QAM (optional). In this paper we have shown the simulation results using QPSK and 16-QAM.

To get high data rate now OFDM was used as the physical layer for WIMAX [7].The main disadvantages of OFDM is its high PAPR. High PAPR indicates that a highly linear power amplifier is required at the transmitter. So the dynamic range of the power amplifier becomes more hence the cost increases and the battery life time decreases. So now the PAPR reduction has a vital effect on the mobile communication. There are many methods [3] exists for the PAPR reduction. Out of which SLM [1] is a promising technique. According to this technique the main data block will be divided into several independent blocks then each will be converted into OFDM symbol and finally the symbol which has less PAPR will be transmitted. Here we are showing the performance in baseband transmission.

PAPR is the ratio between the maximum power and the average power for the envelope of a baseband complex signal $\tilde{\boldsymbol{x}}(\boldsymbol{t})$ i.e.

$$PAPR\{\tilde{x}(t)\} = \frac{max|\tilde{x}(t)|^2}{E\{|\tilde{x}(t)|^2\}} \quad (1)$$

This paper is organized as follows: In Section II, the SLM technique is presented. In Section III the simulation results for the WIMAX parameters are shown. Finally in Section IV conclusion is proposed.

I. SLM TECHNIQUE

The classical SLM technique was described in [1]. According to this technique we have to find out independent phase vectors. The number of phase vectors will be same as the number of candidate vectors i.e. let $'M'$.

So the nth point of mth phase vector is given as

$$B(m,n) = e^\wedge(j\Phi(m,n)). \quad (2)$$

Where $m \in \{1,2 \ldots \ldots \ldots . M\}$
$n \in \{0,1 \ldots \ldots \ldots . . N-1\}$
$N =$ The number of subcarriers

In the classical SLM technique

$$|B(m,n)| = 1. \quad (3)$$

The random phases $\Phi(m,n)$ will be taken according to [4, 6]. Then we will multiply the data to the phase vectors to find out the candidate vectors and after doing the IDFT operation the OFDM symbol having minimum PAPR is to be transmitted. So to recover the transmitted signal at the receiver, the information about the multiplied phase vector will be required to send along with the OFDM symbol i.e. known as the SI index. If due to some sort of error the receiver cannot detect the perfect SI index then the exact transmitted data block from that OFDM will not be recovered.

But in paper [2] a new SLM technique was described by which we can recover the original transmitted vector without sending any SI index along with it.
According to this new SLM technique at some points for $n \in \{0,1,\dots\dots\dots.N-1\}$, $|B(m,n)| = C$. Where, $C > 1$ is known as the extension factor. Then at the receiver side the SI index will be detected according to the algorithm described in [2] .We have applied this technique in the WiMAX environment. Here the analysis was done to show that if we apply this SI detection technique at the receiver, what will be the effect on the bit error rate performance and also how much error occurs for detecting its SI index.

II. SIMULATION RESULTS USING PARAMETERS OF WIMAX

In this paper we assume the transmission channel as a quasi-static frequency selective Rayleigh fading with equal power taps. We also assume the use of nonlinear solid state power amplifier (SSPA) [5] at the transmitter output.
The parameters of WIMAX that are to be used are given as follows:

$$N = Number\ of\ Data\ subcarriers = \{70{,}720\}$$

$$Cyclic\ Prefix = \begin{Bmatrix} round\ \left(\frac{N}{8}\right)\ for\ N = 70 \\ round\ \left(\frac{N}{32}\right)\ for\ N = 720 \end{Bmatrix} \quad (4)$$

The modulation schemes to be used for the simulation work are QPSK and 16 QAM.
During the calculation of PAPR for the different data sub carriers used in WiMAX we have to consider the over sampling factor. As the actual data transmission is in Analog form but we are analyzing here in digital form. So to get perfect PAPR the oversampling factor is to be considered.

$$x(n) = \frac{1}{\sqrt{N_s}} \sum_{k=0}^{N-1} X(k) e^{\frac{j2\pi nk}{N}} \quad (5)$$

Where $x(n)$is the discrete time base band OFDM signal and $\frac{N_s}{N}$ is the oversampling ratio. This is also known as the $N_s$point inverse fast Fourier transforms (IFFT). Here the power amplifier was considered before transmitting the OFDM signal having minimum PAPR. For the simulation model of power amplifier use Rapp's model of solid state power amplifier (SSPA) [5] with a smoothness parameter $p = 3$, small signal gain $v = 1$ and an input back off (IBO) of 7 db. For the channel assume $Z = 5$ equal power taps with time domain coefficient h_z' is a complex zero mean Gaussian sample representing the fading experienced by the zth tap. Also consider the noise to be added has mean $\mu = 0$ and variance$\sigma^2 = N_0$, where N_0 denotes the power spectral density (PSD) of the additive white Gaussian noise (AWGN).

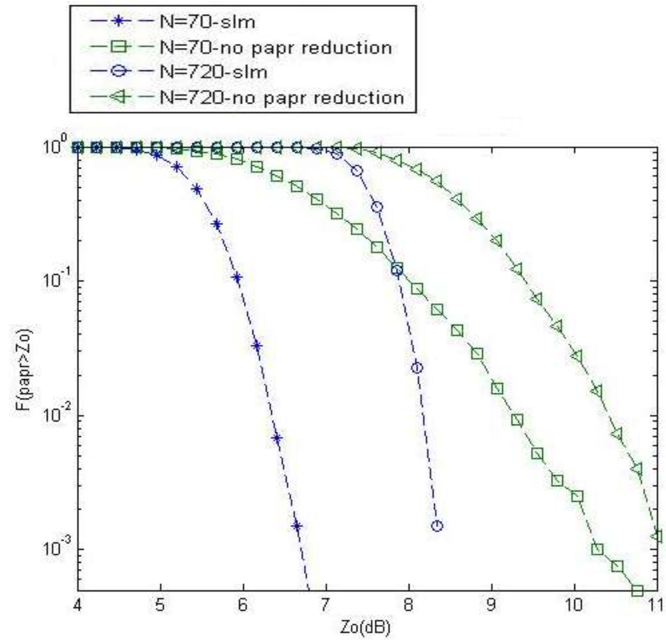

Figure 1 CCDF for the PAPR obtained using new SLM technique for the data subcarriers of WIMAX

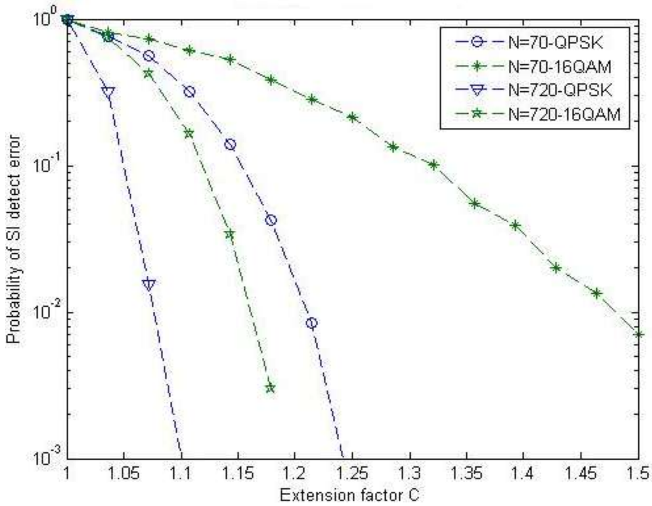

Figure 2 Plot of Probability of error in detecting SI index with respect to increasing in C

A. PAPR Reduction Performance

The fig.1 shows the complementary cumulative distribution function (CCDF) for the PAPR obtained by using new SLM [2] technique for 16-QAM modulation, $C = 1.2$ and $N = 70$, 720. It is to be known from this simulation result that the PAPR is reduced in comparison to the normal OFDM i.e. without using any reduction technique. And also we came to know that with increasing the number of subcarriers we have to compromise with the high PAPR.

B. *Probability of SI detection error*

In addition to PAPR reduction in WIMAX using SLM technique also our aim is to avoid the transmission of SI index along with the transmitted OFDM symbol. So we get the information from the fig.2 that the probability of error in detection of SI index at the receiver will be less for using QPSK modulation than that of the 16-QAM modulation with increasing the value of extension factor. Also we get that increasing the number of subcarriers results in a lower probability of detection error this is due to the fact that the C is repeated many times in a phase vector. The algorithm used to get the probability of error in SI index detection was described in [2]. This algorithm performs well for QPSK modulation than 16-QAM due the reason that the energy per symbol for QPSK is constant.

C. *Bit error rate Performance*

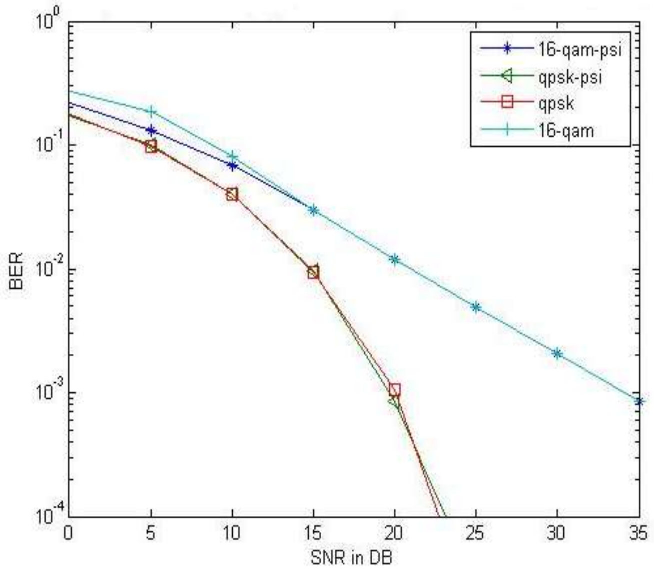

Figure 3 BER performance with considering N=720

Bit error rate analysis is very important in communication systems. The plot of this analysis is shown in the fig. 3 for N=720. Also the quasi-static frequency selective Rayleigh fading is to be considered. Here for one modulation scheme two graphs are shown, one is with consideration of the perfect SI index detection at the receiver and the other is with application of sub optimal algorithm at the receiver. For QPSK modulation the two graphs are same because the energy per symbol is constant but for 16-QAM it holds good at higher SNR (Signal to Noise Ratio).

III. CONCLUSION

In WIMAX our aim is to get high data rate simultaneously with a long range of communication. So by using the physical layer as OFDM we will get high data rate with decreasing of PAPR using new SLM technique. Our research work performed by considering OFDM scheme based on QPSK and 16-QAM modulation that this technique performs well for the large number of subcarriers. In fact the probability of SI detection error performs well with increasing the value of extension factor and/or the number of subcarriers. If we use this technique in WIMAX we have to pay significant price for the increase in complexity at the receiver due the use of a SI detection block.

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